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Mining Engineers' Association of India

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## this issue contains...



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# President's Message.....

Dear Readers

Greetings!

In less than a month, things have completely changed. Crowing about India's exceptionalism in "beating" the epidemic - younger population, native immunity, a largely rural population - and declaring victory on the virus has turned out to be cruelly premature. India is in the grip of a devastating second wave of the virus and cities were facing fresh lockdowns. Urge every citizen to take precautions and follow a Covid appropriate behaviour.

The notification of the MMDR Amendment Act 2021 has marked the dawn of a new era in the Indian Mining Industry with the inclusion of plethora for positive forward-looking amendments like removal of distinction between captive and non-captive mines, removal of transfer charges, selling permission to captive mines, amendment to section 21(5) etc. The changes proposed in the Draft Minerals (Evidence of Mineral Contents) Amendment Rules 2021, released for stakeholder consultation, like the proposal for auction of Mining lease with Preliminary Exploration (G3) level and proposal for auction of Composite licence with Reconnaissance Survey (G4) is a testimony to the Government's efforts to streamline pending development of the Indian Mining industry.

The constitution of a Committee under the chairmanship of ex- coal secretary, having representation from Ministry of Mines, Ministry of Steel , Niti Aayog and IBM to examine the issue of double calculation in case of Royalty and developing the National Mineral Index is a welcome step by the Government.

MEAI has been continuing with its journey of imparting and sharing knowledge on various aspects of mining, through the webinar series organised by its various Chapters and this initiative fills me with pride and gratitude.

Hyderabad Chapter organized an International Webinar on "Advanced Blasting Techniques" in association with the NMDC. The papers presented by various authors during the webinar enriched the participants with latest technology used in Blasting and ways for its robust implementation.

A three-day National virtual conference titled " National Mineral Policy - 2019-Way Forward towards Aatmanirbhar Bharat & Make in India" was organised by Hyderabad Chapter. The virtual conference marked a great success and technical sessions on topics like Mining Legislation, Exploration through Innovation, Mining Methods-Latest Technologies, Mineral Processing through latest technology, Mining and its impacts on Environment and Implementation of IT in Mining were presented during the conference.

It gives me immense pleasure to share with the esteemed readers that Bangalore Chapter has started its own office premises in the heart of Bengaluru city last month. It marks another feather in the cap of MEAI. I Congratulate Bangalore Chapter Team for this notable achievement. It will surely encourage other Chapters too in expanding the reach of MEAI and further glorify the journey.

My hearty complements to all the Members of Bhubaneswar Chapter for organising a Panel discussion titled "MMDR Amendment Act, 2021 and its impact on Mining Industry" wherein experts on the subject from Regulatory Bodies, Government functionaries and Industry shared their views on the recent amendments in the Act.

With this I would like to once again request the readers to take utmost care against the virus spread and take vaccination as per their eligibility. Together we can flatten the rising Covid curve and emerge victorious from these testing times.

With Best wishes

**Sanjay Kumar Pattnaik**
President

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# EDITOR'S DESK

**Dr. P.V. Rao**
Editor, MEJ

The recently amended MMDR Act 2021 brought exuberance in the mining industry on numerous counts. Nonetheless, interchange of views between the lawmakers and bureaucrats; and the leaders of the mineral industry and professional bodies ostensibly developed numb as there was little or no debate emerged on the draft mineral laws in the social media or the professional bodies' platforms. Does it anyway reverberate my way or highway attitude of the lawmakers / bureaucrats towards stakeholders while framing the mineral laws of national importance? Unambiguity and transparency shall be the hallmark of any mineral laws drafted to protect the interest of investors. In this context, let me share my observations on the recently amended MMDR Amendment Act 2021 and the follow-up draft Mineral (Auction) second amendment rules 2021 and Minerals (Evidence of Mineral Contents) Amendment Rules, 2021 released on April 23, 2021 for stakeholders consultation, specific to mineral resources reporting for the auction purpose. Mineral resources form the foundation in the valuation of a block for bidding.

Point #2 (Page1) in the draft Mineral (Auction) second amendment rules 2021 states that two major changes are brought out to increase pace of exploration and bring more blocks into auction - (i) to initiate auction for composite licence (PL cum ML) at G4 level of exploration and auction the ML for surficial (Limestone etc) at G3 level and (ii) for inclusion of the globally accepted classification standards like CRIRSCO, JORC, etc. and latest UNFC classification. Let me clarify that CRIRSCO, unlike UNFC, is an internationally recognised public reporting standard for Mineral Resources and Reserves. Moreover, quoting CRIRSCO and JORC alongside only shows the trivial understanding of the subject experts in this matter. Domain experts would have liked to frame this sentence as '(ii) for inclusion of the Indian Mineral Industry Code (IMIC), which is a CRIRSCO compliant, as the public reporting standard in India and the latest UNFC classification for maintaining the National Mineral Inventory'.

*'(ii) for inclusion of the Indian Mineral Industry Code (IMIC), which is a CRIRSCO compliant, as the public reporting standard in India and the latest UNFC classification for maintaining the National Mineral Inventory'*

Disregarding valuable suggestions offered by domain experts during the stakeholders' consultation process could only lead to such an impulsive draft. It is high time for the Indian government to adopt the Made in India 'IMIC' that has been duly approved and recognised by CRIRSCO at par with the other 13 CRIRSCO compliant codes for public reporting of Mineral Resources and Reserves. Refusal to recognise the IMIC echoes the government's lack of confidence on the capabilities of its domestic think tank or exuberance in promoting other countries' Codes that are no way different from IMIC.

Composite licence auction at G4 level looks rational because the investors knew that they were bidding for blocks where no mineral resource could be assessed at the time of bidding. The onus lies on the bidder to conduct reconnaissance research to assess the block potential before bidding. Auction of the ML at G3 level, though limited to surficial deposits like limestone, remains vague because of limited availability of exploration and technical data offered in geological reports. It is further silent on the auction of ML for other types of mineralisation, including concealed deposits.

As per draft MEMC Amendment Rules, 2021, a block can be auctioned as ML if the block is explored by preliminary exploration (G3) and classified as Inferred Mineral Resources (333). It further states that Inferred Mineral resources (333) cannot be converted into Mineral Reserves signifying that one cannot conduct pre-feasibility or feasibility studies. The Inferred Mineral Resources are intrinsically economic (E3) implying that they may or may not have immediate economic value and only geological study (F3) has been conducted. Then how can a successful bidder of the block start mining without established mineral reserves in an ML?

The MEMC 2015 rules, which were framed with the standard definitions, cut and paste from CRIRSCO Template 2013 and / or UNFC 2009, attracted intense criticism from the stakeholders on the unprofessional drafting of these rules. The technical experts involved in framing the draft MEMC 2021 rules however tried to mitigate the earlier criticism by simply excluding some of the critical criteria indispensable to definition of Mineral Resources and Mineral Reserves under standard definitions, reflecting the fact that the geoscientists with limited mining industry experience drafted these definitions. It is important to appreciate the essential fact that the Mineral Resources and Mineral Reserves cannot not be classified based on G-axis data alone as the other two axes E & F play a much bigger role as far as the investors requirements are concerned. Thus, the draft MEMC 2021 rules in their extant form might not instil the desired confidence in the investors to attract their participation in the auction process in a big way. Let us not further waste and delay by another five years or even more valuable time in fostering the growth of the Indian mineral sector.

***- Editor***




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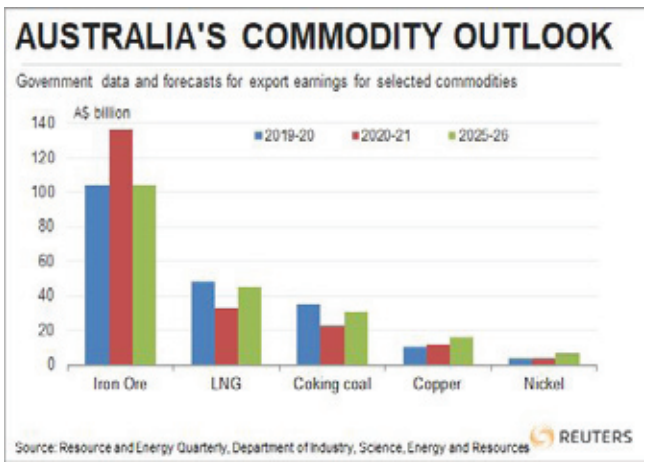
# NEWS FROM THE MINING WORLD

## ➤ Resource-rich Australia shows vagaries of any commodity supercycle: Russell

For those seeking evidence of a new commodity supercycle, and for the sceptics of a sustained boom in natural resources, Australia's government forecaster has it covered.

The government's latest Resources and Energy Quarterly report, released on Monday, illustrates how some commodities surged during last year's coronavirus pandemic, and also how the gains weren't across the board and may not be easy to sustain. The media-grabbing headline of the report was that the nation's resource and energy exports are set to reach a record A$296 billion ($226 billion) in the fiscal year to June 30, 2021.

Australia is the world's largest exporter of iron ore, liquefied natural gas (LNG) and coking coal used to make steel. It ranks second behind Indonesia for thermal coal and third in shipments of copper ore, and is a major producer of both aluminium and alumina, the raw material used to make the refined metal. Australia is also the world's third-largest gold producer and the biggest net exporter of the precious metal, and is a top supplier of battery metals such as nickel and lithium.




The stellar performance for the country's resource sector this fiscal year was largely driven by top export iron ore, which is forecast to account for A$136 billion, or just under half, of the total value of exports, according to the report compiled by the Office of the Chief Economist of the Department of Industry, Science, Energy and Resources. This is up from A$104 billion iron ore exports in the 2019/20 fiscal year, achieved on both higher volumes (up 4%) and prices (up 41%).

The massive surge in iron ore earnings was largely a story made in China, as the world's biggest importer of the steel ingredient spent to boost its economy after the hit from the lockdowns imposed to stop the spread of covid-19. China's impact can be seen in some of Australia's other commodities, with export earnings for copper gaining 20% to A$12 billion even though volumes shipped were slightly lower.

It's worth noting, though, that apart from iron ore and copper, only gold export values rose in 2020/21, to A$29 billion from A$25 billion. The rest of Australia's major resource and energy exports declined, including LNG, crude oil, alumina, aluminum, zinc, lithium and both grades of coal. Lower prices for much of the fiscal year were largely to blame, although these did start to recover over the past few months.

### Super cycle, what super cycle?

Much of the commodity super cycle story is built around ongoing high demand for resources from China, coupled with a synchronous boost from much of the rest of the world as countries act to boost growth through infrastructure spending.

There is also the expectation that supply for key commodities will struggle to keep up, given weak investment spending by producers in response to the sharp declines in prices in the early stages of the pandemic. The Australian government report lends some credibility to the demand side of the super cycle vision, but only for commodities most exposed to China's industrial might, namely iron ore and copper.

While others, including battery metals, are also showing signs of recovery, energy products have been propped up by temporary factors, such as producer output cuts in the case of crude oil and a cold northern winter for LNG. Where the report becomes more interesting is in its longer term outlook, which doesn't see much of a demand-led super cycle, with Australia's resource and energy exports forecast to rise to A$321.1 billion by 2025/26, a compound annual growth rate of just 1.7%.

This would be a solid, unspectacular outcome, although far removed from a super cycle story. Delving into the breakdown shows that the commodities the report expects to do best correlate to the energy transition, with export earnings from lithium expected to jump some 440% from the current fiscal year to A$5.4 billion

in 2025/26, while nickel will almost double to A$6.5 billion, and copper rise by 33% to A$16 billion.

In contrast, iron ore, star of the current year to end-June, is forecast to fade by then to A$104 billion – the same level as in 2019/20 – while LNG will stay relatively stable and both grades of coal will see declines. Overall, the report shows two things, firstly that the evidence for an emerging commodity super cycle is somewhat mixed, and secondly that while some commodities are likely to do well over the coming years, the gains won't extend to all.

*Reuters | March 30, 2021*

## ➤ Congo launches state-owned cobalt miner

The Democratic Republic of Congo (DRC) has officially begun operations at Entreprise Générale du Cobalt (EGC), a state-owned company with monopoly rights to the purchase and sale of the country's hand-mined cobalt.

EGC, created a year ago to help control artisanal supplies and boost government revenue through price controls, will sell cobalt hydroxide under a five-year contract with trading house Trafigura. The non-exclusive supply deal will also see Trafigura finance the creation of strictly controlled artisanal mining zones, buying centres and logistics to trace supply. DRC holds around 70% of the world's reserves of cobalt, crucial for the lithium-ion batteries used in the fast-growing electric vehicle (EV) sector.

Congo's artisanal miners are the world's second-largest source of cobalt after the country's industrial mines. Consultancy CRU expects the DRC to produce more than 100,000 tonnes of cobalt this year, or 71% of the global total, of which 8,000 will come from artisanal sources. Child labour and a lack of safety measures in artisanal mining are behind many initiatives to formalize the sector.

According to Amnesty International, children as young as seven have been found scavenging for rocks containing cobalt in the DRC. The group also claims to have evidence that the cobalt those miners dig has been entering the supply chains of some of the world's biggest brands. "All of us engaged in this endeavour are aligned in a firm commitment to collaborate transparently with our stakeholders and to ensure that together we create effective solutions for responsibly sourced cobalt," Jeremy Weir, Trafigura executive chairman and CEO said in the statement. "Ultimately, we believe that a formalized artisanal mining sector can transform lives and serve as a catalyst for economic growth in the DRC," he said.

### Cleaning up the sector's image

EV makers including Tesla and Volkswagen have recently vowed to help improve working conditions in the DRC. The metal, a by-product of copper or nickel, is an essential metal in the production of the batteries that power EVs and high tech devices. China's biggest cobalt producer, Huayou Cobalt, which supplies to LG Chem as well as Volkswagen, said last year it would stop buying from artisanal miners in the DRC.

Trafigura has been involved in efforts to monitor and improve artisanal cobalt mines in the Central African nation since 2018. That year, it opened a pilot project to formalize informal miners at Chemaf Sarl's Mutoshi mine. After raising $450 million in 2019 for the facility, Trafigura had to suspend the project in March last year due to the global pandemic.

Official figures show that more than 200,000 people make their living digging cobalt and copper in Congo's southeast Katanga region. EGC is a wholly owned subsidiary of state-miner Gécamines. The new company has not disclosed the terms of its agreement with Trafigura.

*Cecilia Jamasmie, Mining.Com | March 31, 2021*

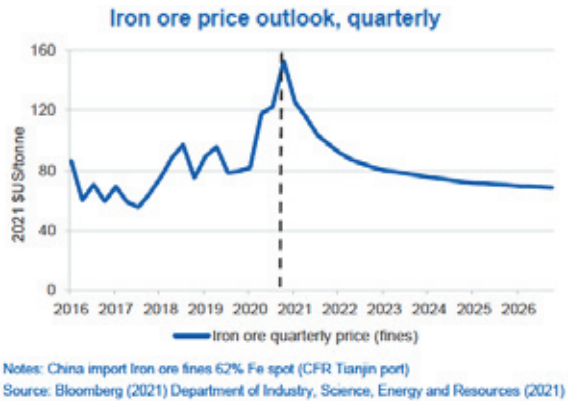
## ➤ Top iron ore producer forecasts 50% fall in price

Iron ore was the best performing commodity in 2020, thanks to China's early emergence from the pandemic and Beijing's heavy spending on economic stimulus, particularly infrastructure. Iron ore prices have eased since hitting levels last seen in 2011 at the beginning of this month, but at $167 a tonne are still 90% higher than this time last year.

China consumes 57% of the world's iron ore and controls more than two-thirds of the seaborne trade. Australia's share of world trade is 53% and although relations between the two countries have soured, when it comes to iron ore they are joined at the hip. Australia's department of industry's quarterly report outlines a bonanza for the country with annual iron ore export values expected to peak at A$136 billion ($103bn) in 2020–21 and stay above A$100 billion for the next five years.

The strong earnings are thanks to new mines and expansion projects coming online, which will push Australia's iron ore exports from 900 million tonnes

currently to 1.1 billion tonnes by 2025–26. The outlook for prices, however, is far less rosy. Australia's office of the chief economist sees a range of factors putting downward pressure on prices over the coming months. Some price falls are expected, as Vale's Brazilian operations steadily return to output levels prior to the January 2019 Brumadinho dam collapse. Overall, Brazilian output is expected to recover to normal levels by the end of 2021. More rapid progress on this front could lower prices more swiftly.




Chinese steel mills, which are facing severe pressure on margins, may also seek to postpone some output in order to manage price pressures over the coming months. Chinese Government stimulus measures could also be phased down in the second half of 2021, reducing the imperative for rapid purchases of iron ore to meet production schedules and allowing some build-up of iron ore at ports.

While price spikes are likely as a result of disruptions due to extreme weather in the two main supply regions of Western Australia and Brazil, the longer term outlook for the iron ore price is squarely in double digits. Prices are expected to halve by the end of next year and then gradually decline to reach $72 a tonne in real terms by the end of 2026.

*MINING.COM Staff Writer | March 30, 2021*

➤ **India delays anti-pollution rules for coal power plants again**

India's environment ministry delayed anti-pollution guidelines for coal-fired power plants further, extending the compliance deadline by as long as two years. Plants located close to populated cities, including capital New Delhi, will now have to meet the standards by December 2022, a seven-year extension from the original plan to cap toxic emissions, including particulate matter, sulfur dioxide and oxides of nitrogen, according to a March 31 notification.

Units close to critically polluted areas have until end-2023 to comply, while those located in less polluted smaller towns can wait on retrofits until the end of 2024. Plants approaching closure have been exempt from the exercise, according to the notification.

Most Indian coal-fired generators have resisted installing the retrofits, citing financial stress and lack of clarity on recovery of their investments. They have found support from the power ministry, which successfully pushed for extending the original deadline and later made a case to the environment ministry for sparing plants in areas with good ambient air quality. The cost of retrofits has added to concerns of owners of coal-fired plants that their electricity prices will become less competitive against renewable power, whose prices have been declining.

"It is very unfortunate that environment ministry sides with the polluters and law offenders time and again to give them extensions and dilutions rather than with the common public who is suffering from severe pollution and health impacts and whose interest the ministry is duty-bound to protect," Sunil Dahiya, a New Delhi-based analyst at the Centre for Research on Energy and Clean Air, said in a text message.

Coal, which helps produce about 65% of India's electricity, has been linked to the choking air pollution in its cities, as well as diseases and premature death of thousands of citizens. The environment ministry introduced the pollution guidelines in 2015, giving the power companies two years to meet the targets. The deadline was later extended in a revised schedule that stretched until 2022, but most plants are expected to miss that too.

In its latest notification, the environment ministry placed a monetary penalty on those who miss the deadlines. Plants will pay as much as 0.2 rupees a kilowatt hour of power they generate, with the amount varying on with their location and the duration of default.

*Bloomberg News | April 4, 2021*

➤ **Goa mining impasse needs holistic approach for redressal**

Goa, the smallest State in India, is blessed with abundant mineral deposits such as iron ore, manganese ore, bauxite and so on. Tourism and mining have been the mainstay of Goa's economy and these two sectors are the major sources of livelihood for the locals.

Due to the mining stoppage, the State was already faced with the perilous problem of falling revenue and

the same has been exacerbated due to the COVID-19 pandemic, leading to Goa witnessing its worst economic crisis. The State is borrowing extra money to the tune of Rs 100 crore every month through the Reserve Bank of India (RBI) in the current financial year to bridge the fiscal deficit which will further add to the financial woes and create a debt crisis in the State.

Mining has been a very important element in the economic history of modern Goa and played a significant role as foreign exchange earner for the nation. Mining in Goa today is synonymous with iron ore mining, which is entirely with the private sector. It has a long-cherished history of systematic and scientific mining and won accolades from different organisations across the globe.

The exemplary "reclamation and rehabilitation" of mined-out areas carried out in some mines in the State has attracted the attention of the mining world not only in India but also globally and used to be referred to by experts on different platforms. However, the low quality of iron ores, coupled with more removal of huge quantity of waste for every tonne of ore production (excessive stripping ratio) and comparatively higher transportation charge as compared to the iron and steel plants located on the eastern coast of India, made it economically unviable to compete in domestic markets and thereby left the Goan miners with no option but to look to the overseas markets. Thus iron ores produced from Goa is exported to various countries like Japan, South Korea, Taiwan, China and others.

Nevertheless, the iron ore mining in Goa is beset with certain problems/ issues like dumping of mine waste/ refuse outside the leasehold — due to limited leasehold area and unavailability of non-mineralised area in the mining lease —and use of existing public transport infrastructure for transportation of the iron ore.

Mining operations have been completely stopped in Goa from March 16, 2018, ever since the Supreme Court cancelled second renewal of 88 mining leases in the State vide its order dated February 7, 2018. It has disrupted not only the mining sector but also the entire ecosystem of allied industries, including individual truck owners, barge workers/owners as well as equipment suppliers, machinery owners, port workers, small garage owners, tea and refreshment selling stall owners and so on.

On the other hand, tourism, which is another full-fledged industry of the State supporting large section of population, also suffered badly due to the pandemic. During the COVID-19 lockdown and even afterwards, the tourism industry has come to a standstill while complete shutdown of mining in the State continues to create unprecedented employment crisis adversely impacting the livelihood of more than three lakh people. Also, it has a direct bearing on the State revenue, resulting in loss of more than Rs 3,500 crore every year as per the State Government estimates.

The State Government has filed a review petition against the order of Supreme Court regarding cancellation of mining leases while some mining companies have also filed petitions before the apex court with respect to the applicability of the "Abolition Act 1987".

In order to unlock the mining impasse prevailing in Goa, the following multi-pronged strategies are suggested: The Central Government should come forward to resolve the issue of date of applicability of Goa, Daman and Diu Mining Concessions (Abolition and Declaration as Mining Leases) Act 1987 (popularly known as the Abolition Act 1987).

The Bombay High Court had previously held that the Central Government could only recover statutory dues from 1987 onwards that is prospectively under the Abolition Act as against retrospectively as was claimed.

The Supreme Court should decide clearly on the matter, any other solution is likely to further muddle the situation and would lead to inordinate delays in mining resumption which is likely to aggravate the precarious financial condition of Goa and its people.

There is little hope of revival of tourism industry in the State till the time COVID-19 pandemic recedes. This makes it imperative to take immediate corrective actions to find a solution to the Goa mining crisis and prevent further loss to the State's economy.

The socio-economic impact of mining ban in Goa may lead to a serious humanitarian crisis if there is any further delay in finding a timely solution to the current stalemate.

*The Pioneer, Cletus d'souza | April 9, 2021*

➤ **In depth interview: Friedland on the new world order**

Robert Friedland, the founder and executive co-chairman of Ivanhoe Mines (TSXL IVN; US-OTC:

IVPAF) gave a keynote presentation at this year's virtual CRU World Copper Conference. Filmed from his home in Singapore on April 13, the billionaire spoke about what the electric future will look like and what needs to happen to the supply chain to get there. He also called copper a "national security issue." What follows is an edited transcript of his comments:

"We're here to talk about the revenge of the miners and how important it is that we sustainably mine copper metal for the new world economy. We spent about 100 years where the principal real reason for fighting wars was hydrocarbon. War! Hydrocarbon! And now we see hydrocarbon relatively less important over a period of say a generation; for a generation and a half. And so we now see the balkanization of the world economy, where Greater China has been focused on their energy security, on their own industrial transformation, their own electrification, the improvement of the environment for their own people, top to bottom, eliminating water pollution, air pollution, electric transportation. And then a fear of Europe and the United States. That they also have to secure their entire, top to bottom, supply chain, and that leaves people out, like the Japanese, or the Koreans, or the Indonesians, or the Brazilians, wondering about their supply chain. And so as each block starts worrying about the national security implications of their supply chain, this balkanization of what was a perfectly integrated world economy the last ten years, is inherently inflationary, and inherently involves the duplication of effort.

If an American went to a Walmart store the last ten years, to buy some cheap consumer goods, they were invariably made in China. And even now, America's trade deficit is super-high with China. And if that lawnmower, or that microwave oven, or that washing machine is not made in China, it's going to be a lot more expensive. And so we're seeing a lot of inflation coming up in the system, and we see the Federal Reserve Board and other monetary authorities whistling in the dark, they've been so worried about, well let's say there's a man walking over Niagara Falls, on a tightrope, balancing, and if he's going to fall off on the left, that's deflation. And that's been the big fear. So the Federal Reserve board says oh we're going to tilt towards the inflationary side. Obviously the danger is that they're going to overdo it, and fall right over the other side. We're seeing inflation in the price of good geologists. We're seeing inflation in the price of raw material input already. If you want to buy mining equipment; if you want to find the copper and mine it, as the world demands copper, and nickel, and cobalt, and aluminum and electrically conducted metals, we're going to see a lot of inflation.

So in mining, we know what to do when things are really cheap, and we know what to do when things are really, really expensive, and we're somewhere in the middle heading towards expensive. We're just in the early stages of reflating the world economy and balkanizing the world economy; and each country is very, very nervous. I'm here in Singapore, a little island 623 sq. km, no crude oil, no water, no agricultural potential worthy of mention; importing everything from their neighbours, and around the world, and they wake up and say wow, we have to reinvent ourselves."

*MINING.com Editor | April 16, 2021*

➤ **Nuclear scanning allows for better detection of precious metals in drill cores, scientists say**

Australian researchers are proposing the use of a nuclear scanning technique to detect the presence of precious metals and strategic minerals in core samples.

The approach involves using modified neutron tomography instruments to make them work in a fast, cost-effective and non-destructive way to map the concentration and distribution of minerals in rock core.

In detail, a team from the Australian Nuclear Science and Technology Organisation (ANSTO) and Macquarie University enhanced the former's neutron tomography instrument Dingo, which generates images similar to those of an X-ray CT scan but instead uses neutrons, neutral subatomic particles. The particles are produced by the Open-pool Australian Lightwater Reactor (OPAL), a 20-megawatt swimming pool nuclear research reactor.

Before moving into this phase, they developed a rig to hold the cores they were going to study for parallel scanning. The cartridges in the device can hold four cores up to 1.5 metres in length, with a maximum diameter of 80 mm each.

The specific cores used to test ANSTO's concept were provided by Aurelia Metals (ASX: AMI) and were extracted at the company's Hera gold-lead-zinc-silver mine in New South Wales.

The Dingo instrument then produced a three-dimensional image reconstruction of the drill core, which was achieved by rotating the cores in the

neutron beam while acquiring thousands of shadow radiographs. The radiographs were then converted into 3D visualizations of the drill cores.

According to the scientists, the data generated from the radiographs can be used to extend 2D surface mineral maps achieved using X-ray fluorescence to more accurately report mineral content within entire drill cores.
“Our collaborators at Macquarie University were satisfied that the images were viable for mineralogical assessments and are developing new methods to explore and integrate these datasets into geological and geochemical analyses,” said Joseph Bevitt, one of the researchers involved in the experiment.

In Bevitt’s view, depending on the desired scan resolution, non-destructive neutron CT scanning of one-metre drill core lengths can be completed in an hour.

He pointed out that, at present, industry and research institutions use X-ray techniques for high throughput drill core inspection and analysis. However, X-rays cannot penetrate samples that contain abundant heavy metals, such as lead, without losing image contrast.

“Neutrons overcome this limitation as lead, and a number of other commonly occurring minerals that are problematic for X-rays are more transparent to neutrons,” Bevitt said.

For the expert, however, combining the capabilities of both X-ray and neutron CT scanning may be the next big thing to support holistic 3D mineral mapping. This is why his team is also planning to install an X-ray source to enable bi-modal neutron and X-ray tomographic imaging of drill cores.

*Valentina Ruiz Leotaud | April 18, 2021*

## ➤ Private sector companies seek 'level playing field' for coal block auction

There are about 80-100 coal blocks which are likely to be auctioned in multiple phases over the next few years

Private sector companies scouting opportunities for commercial coal mining in the country are seeking a "level playing field" to encourage them to participate in the bidding process, sources said on Tuesday.

Given the international scenario, global mining companies are looking to gradually reduce their exposure and investments in the coal sector and this will have an impact on FDI in commercial mining, private companies' officials said.

"If the government does not provide the level playing field to private sector firms for commercial mining, the interest among mining firms will not take-off as it was envisaged earlier," an official of the country's leading private sector conglomerate told PTI.

The opening up of commercial coal mining for private sector is the most ambitious reform since the nationalisation of this sector, ending the monopoly of state-owned Coal India Ltd (CIL).

Ministry of Coal is holding consultative meetings in various cities with the stakeholders to discuss the draft methodology as well as key bidding terms and conditions for auction of coal mines for commercial mining.

A closed-door consultative meeting on the proposed coal block auction for commercial mining was held in the city on Tuesday and some 15-20 representatives from mining companies and associations participated in it, sources said.

Many stakeholders stated that a "penalty clause" is a major deterrent and will "not encourage serious commercial miners to participate in the bidding process".

Explaining about "level playing field", the official of the private sector company said that there is "no penalty clause" in case of Coal India while they will have to bear a risk to pay, if production quantity is below a threshold level

"We have also sought clarification about computation of the penalty for production below 70 per cent of the targeted output in three years," the official said.

Central Mine Planning & Design Institute Ltd chairman Shekar Saran said the government has relaxed several conditions to make bidding attractive.

"The Centre expects large participation in the auction process," he said.

However, officials private sctor companies said several financial institutions and mining majors had either stated to exit coal business or given a roadmap to reduce their exposure toward the polluting sector.

Coal sector analysts claimed that after cancellation of allocations of captive coal mines by the Supreme Court, some 80 blcoks were auctioned and only 18 projects had taken off.

The government had said that the first round of auctioning of blocks for commercial mining is expected to be launched in the current fiscal.

There are about 80-100 coal blocks which are likely to be auctioned in multiple phases over the next few years.

*Press Trust of India, Kolkata | Jan 28, 2020*

## ➤ SBI drags feet on loan to Adani firm for controversial Australian coal mine

Bank's executive committee, which will make the final decision, hasn't had discussions about the loan this year, reports Bloomberg.

India's largest bank hasn't decided whether to help finance an Australian coal mine following mounting pressure from climate activists and investors, including BlackRock Inc.

Two senior State Bank of India executives, who asked not to be identified, said the bank was dragging its feet on extending part of a funding line of as much as $1 billion to Adani Enterprises Ltd., which plans to use the money for the controversial Carmichael mine. The bank's executive committee, which will make the final decision, hasn't had discussions about the loan this year, the officials said.

The Carmichael mine has been the focus of environmental protests since it was proposed in 2010. SBI shareholders have joined the opposition. BlackRock and Norway's Storebrand ASA raised their objections over the past year, and Amundi SA divested its holdings of SBI's green bonds because of the bank's ties to the Carmichael mine.

SBI Chairman Dinesh Kumar Khara, who took charge in October, is reticent to disburse the funds to Adani given the opposition to the Australian project, bank officials said. Still, no decision has yet been made about the loan, they said.

Adani said in a statement that construction of the Carmichael Mine is "well underway and we are on track to export" coal in 2021. The company added that its mine and rail projects are fully funded.

- Adani's Carmichael mine in Australia is under scanner over environmental protests.
- In 2014, SBI drafted a pact with Adani for a $1billion facility and brought in several banks to provide the funding.
- But it has not taken a decision on the loan yet as its shareholders - BlackRock and Norway's Storebrand ASA - raise objections.
- Amundi SA divests holdings of SBI's gren bonds because of the bank's ties to the Carmichael mine.

The Adani loan has left SBI, which is majority-owned by the Indian government, in a bind. While foreign investors are increasingly restricting support to companies involved in extracting or consuming coal, since it's the most carbon-intensive fossil fuel, 70% of India's electricity comes from coal plants. The bank has to balance its clean-energy lending policy with the power supply needs of the country, the SBI executives said.

The Carmichael mine is located in the Galilee Basin in the northeastern Queensland province. The mine's license was officially approved by the Queensland government in 2019 and if fully developed, the mine could contribute to an eventual doubling of Australia's coal exports. While that may provide a fresh boon for the country's economy, it would be detrimental to efforts to limit global warming and follows a year when Australia suffered record temperatures and widespread wildfires.

SBI drafted an in-principle agreement with Adani in 2014 for a $1 billion facility and brought in several banks from across the world to provide the funding as part of a consortium. The plan has had several iterations since then as the project became more politically controversial. The memorandum of understanding between SBI and Adani for disbursing the loan included several covenants covering environmental clearance, viability of the project and timelines.

While environmental clearance was granted by the Queensland government, the disbursal is subject to meeting other conditions including funding visibility from other lenders, the two officials said.

*Suvashree Ghosh Alastair Marsh & P R Sanjai | Bloomberg | April 9, 2021*

*(Continued on page 32)*

# COMPARISON OF MINERALIZATION HISTORIES OF TWO EPITHERMAL GOLD DEPOSITS: KOLAR SCHIST BELT, INDIA AND UBENDIAN BELT, WESTERN TANZANIA.

**G.H.Kotnise***

## *Abstract*

*During continental drifting the Indian plate and the African plate which was together drifted apart and the process of gold mineralization was presumed to have taken place at the same geological time. It is reported 80% of the gold deposits are hosted by Archean and Lower Proterozoic greenstone belts. The gold mineralization at Chigargunta in the southern part of Kolar Schist Belt (KSB) and Autrad Mine in Upendian belt at Lupa Gold Field are comparable as the auriferous quartz zones are confined to narrow but laterally continuous shear zones in two distinct litho units viz. in hornblende schist and granitic gneiss. The LANDSAT imageries indicate similarities in structural signatures like shearing and folding in the vicinity of synclinal structure as these structural unconformities are found to be the channels for gold mineralization. In both the deposits, the gold is of epithermal origin attributed to the hydrothermal fluids generated by the magmatic bodies which are rich in gold and rare alkali metals. The gold-quartz precipitation takes place when this geothermal fluid under compressional regime enters these opening through the reverse fault/fracture and as proposed in the 'fault-valve-model'. Gold is associated with sulphides in quartz stringers, little carbonates in shear zones indicate there is a close similarity though the age of their formation varies with the stratigraphic order i.e. Ubendian belt of Precambrian and Precambrian crust of peninsular India respectively. The indicator plant (yellow flowers – Caesalphinacea family) for gold found common as lush growth along the schist belt in both deposits.*

***Keywords:*** *Archean, epithermal, Kolar Schist belt, Precambrian rock, Ubendian belt*

**The author a Consultant Geologist, in Autrad Gold Mine, carried out extensive fieldwork in the Ubendian Belt in Lupa Gold Field (LGF), Matundasi area, Chunya district, Tanzania, and also in Bharath Gold Mines Limited from the early eighties to the closure of the mines in Champion Reef and Nundroog mines.*

## Introduction

In the early part of the 20th Century geoscientists put forth the theory of Continental Drifting which includes fit in the continents, distribution of ancient fossils, rock formations, the occurrence of metals, mountain ranges, fauna, and flora, and other ancient climatic zones. Accordingly, the Indian plate and the African plate which were together drifted apart over geological time (Mahadevan T.M). From the earth's crust, it is reported 80% of the gold mineralization is from both Archean. In the last century search for gold has been the main focus for many countries (Fig.1) (Choukrone et al, 1997).

For comparative study two gold deposits were chosen viz. (i) Autrad deposit located in Ubendian Belt in Lupa Gold Field (LGF) in Archean Craton which is the second largest gold fields in Tanzania within proterozoic mobile belt. Early part of 20th century gold mining carried out in LGF by British colonial regime and by Germans and it is estimated around 24 tons of gold produced. The gold mineralization is associated with quartz vein systems related to felsic intrusives controlled by dominant Saza shear zone trending ENE composed of resistant silicified and ferruginous faulted breccias (Harry Wilhelmiji, 2014) and (ii) Chigargunta is located in the southern part of KSB in east Dharwar Craton,

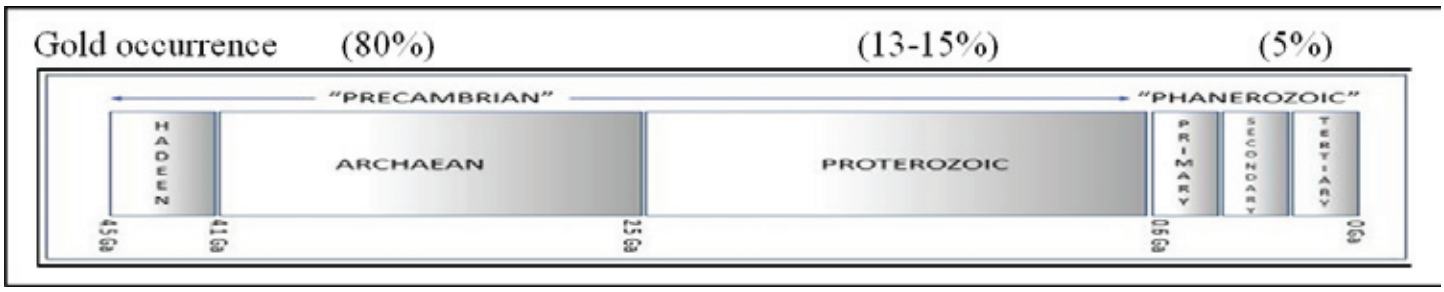



*Fig. 1 Gold occurrence according to geological time scale*

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Kuppam district, Andhra Pradesh, India. The Kolar Schist Belt is located in Archean greenstone belt which has hosted huge gold deposit of around 800 tons of gold mined for over a century at Kolar Gold Fields (KGF) Karnataka,

India There is two distinct host rocks for gold mineralization, amphibolite in the west more prominent than Champion gneiss in the east. Gold occurs in quartz veins confined to narrow but laterally continuous shear zones trending N-S to NNE-SSW in mafic and felsic rock units and in the contact (Mukerjee et al., 1985).

## Geological settings

The geological settings of the gold deposits are as under:

### Autrad mine gold deposit, Chunya District, Tanzania

Autrad mine, the study area is located in LGF (Fig. 2 &3) southwestern part of the Tanzanian Craton within a 1900 Ma old Proterozoic mobile belt known as Ubendian Belt (Mnali, 1969). Audrad mine operate two incline shaft (Fig.4) for underground exploratory development. The LGF is underlain by a block of deformed highly metamorphosed schists and gneisses intermixed with Banded Iron Formation (BIF), volcanic and granitic intrusions (GST, 2008). Gold occurs in quartz reefs in shear zones. Alluvial and eluvial gold deposits are common including placer deposits. The Ubendian belt is comparatively much younger than the oldest Precambrian rocks of the KSB in India. The Ubendian belt has a major Rukwa Rift fault in the SW and Usangu Fault in the SE, near EW trending fault to the north which is considered to be controlling the gold mineralization (McConnell et al., 1950).


*Fig. 2 Tanzania, East Africa location*

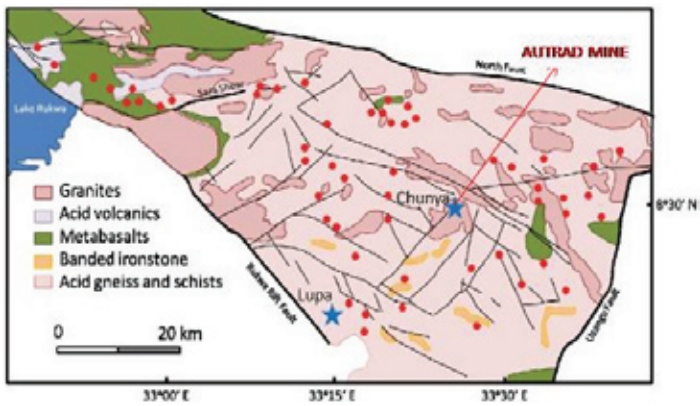


*Fig. 3 Geological map of Lupa Gold Field-red arrow indicate location of Autrad mine.*

*Fig.4 Autrad Mine ATR 13 shaft*

QDS 228/4 Matundasi
Latitude: from -08$^0$ 22' 28.29" to -08$^0$ 24' 00"
Longitude: from 33$^0$ 23' 59.14" to 33$^0$ 23' 59.14"

### Chigargunta gold deposit, Chittoor, District, Andhara Pradesh, India

The Chigargunta gold deposit is located in the southern part of the Kolar Schist Belt (Fig. 6) (Kotnise, 2015) which almost

located in the tri-junction of Andhra Pradesh, Karnataka and Tamil Nadu. It extends over a strike length of 6 km towards the south over a width of 2 km east-west and thins out gradually at Naralapalli, Krishnagiri Dist. Tamil Nadu. The schist belt are surrounded by stretch of gneissic to tonalitic peninsular gneiss. The rocks generally have undergone regional low-pressure crystalline amphibolites facies of metamorphism (Sheshadri et al., 1985).

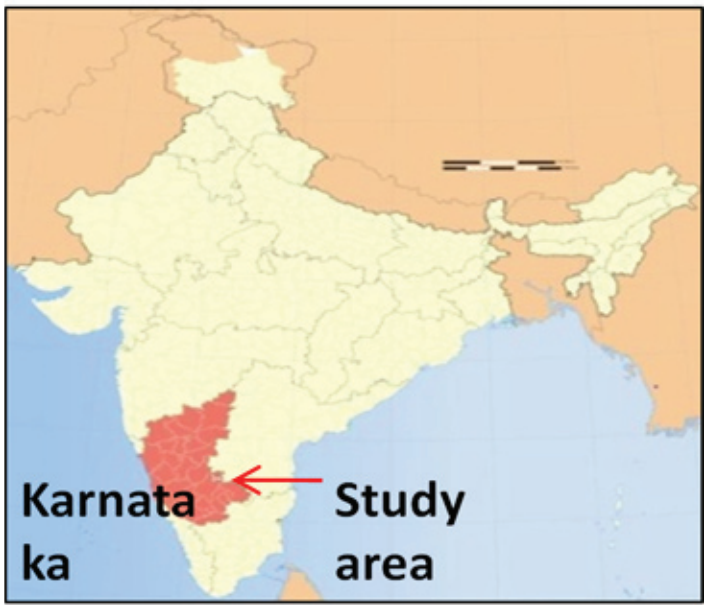


*Fig.5 Location of Chigargunta gold deposit*

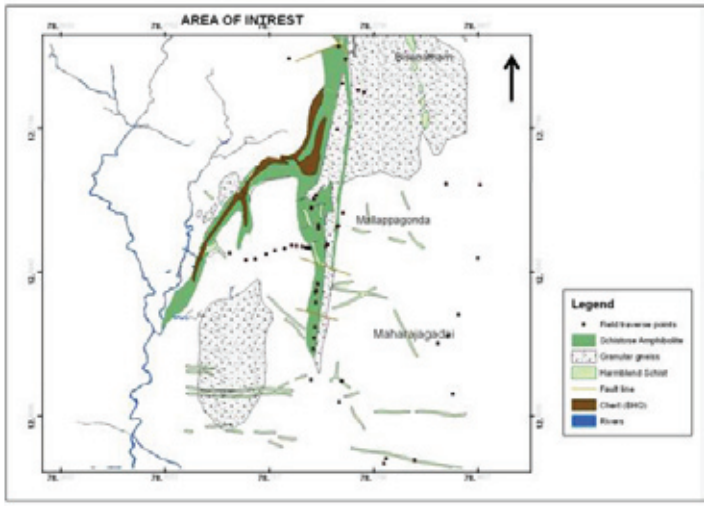


*Fig. 6 Geological map of the southern part of KSB*

Topo sheet No.57 L/2,
Latitude: 12$^0$42'30" to 12$^0$44'00" and
Longitude: 78$^0$ 14'30" to 78$^0$ 15' 00".

This part of the schist belt which trends North-South surrounded by a vast stretch of gneissic rocks of granodioritic to a tonalitic composition known as peninsular gneisses, (Debasish Roy, 2015). The auriferous zones are confined to narrow but laterally continuous shear zones trending N-S to NNE-SSW in mafic and felsic rock units. The quartz reef occurs in the shear zones as stringers associated with sulphide, small carbonate, and ferric oxide (Mukherjee, et al., 1985).

## The objective of the study

Continental drift is identified by coastal fit in both the continents having similarities in litho units, host rock, structural controls, and origin of gold besides the common plants observed in the schist belt. In common the mafic and felsic rocks are associated with sulphide minerals. Orogenic gold deposits are structurally controlled subjected to deformation both ductile and brittle. In this paper, a comparative study on various identical parameters on gold mineralization is discussed. In Autrad deposit since the host rocks are Archean in age and have been later overprinted by proterozoic metamorphism, it is suggested by Groves et al., (2008) that there is potential for major gold deposits to discover in the terrene since they may be re-worked Archean deposits. Hence this study will add interest in discovering a rich gold deposit similar to the gold deposits mined from Kolar mines in KSB.

## Characteristics of gold deposits

The two gold deposits discussed are located in metamorphosed greenstone facies. Gold mineralization occurs in veins related to regional shear/fault zones and lineaments. The satellite image shows hydrothermally altered rocks near the ore body. Gold-bearing gneiss is characterized by foliated and possibly sheared, brown iron oxide weathered, wall rock alteration sheared due to high stress and temperature conditions. Lode is associated with pyrites and carbonates. The comparative characteristics of the two deposits are given in Table-1.

Widespread gold mineralization presents both in basement rock and regolith in LGF. The presence of various late tectonic granite bodies shows that gold mineralization in quartz vein systems related to felsic intrusive (IRGS) (Fig. 7) (Kotnise, 2015).

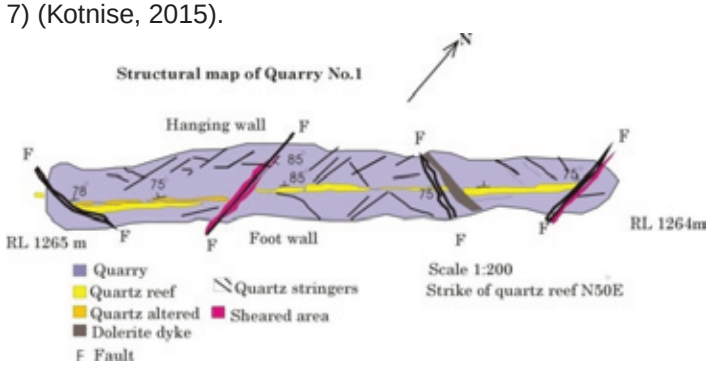


*Fig.7 Structural map of one of the old quarry on which the shafts are erected and operated.*

The primary gold is derived from hydrothermal fluid from huge masses of granodiorites and diorites of the Saza-Chunya granitoid (a batholith?) from the slightly younger Illunga granite. Gold is free as well within arsenopyrite and pyrite.

In Autrad mine in ATR 13 in underground at 30m below surface in exploratory development drive

**Table-1** Characteristics of gold deposits

| Deposit, Region | Chigargunta gold deposit in Southern part of Kolar Schist belt, Kuppam dist AP, India | Autrad gold deposit in Ubendian belt, LGF, Chunya dist., Western Tanzania |
|---|---|---|
| Ore controlled | Three sets of fault overprints folds are NW-SE, NE-SW and E-W set of cross faults | Brittle shear zone faults trend ENE. Regional foliation associated with major dextral shear zones. |
| Host rock | Amphibolite schist/Granitoid Silicified Banded Iron Formation (BIF) | Gneissic formation, felsic gneiss, and hornblende granitic gneiss |
| Magmatic rock association | Hydrothermal magmatic solution derived from granitic magmas emplacement. | Preferred pathway for gold-bearing magmatic fluids brittle shear zones-gold mineralization |
| Geochemical type | Gold-quartz-sulphide | Gold-quartz-high sulphide |
| Ore morphology | Quartz veins, vein-lets, linear stock work zones | Quartz veins, vein-lets, calcite stringers brittle, silicified |
| Wall rock alteration | Quartz-sericite-carbonate-pyrite | Quartz, sericite, goethite, dolomite |
| Mineral composition of ore | Quartz, arsenopyrite, pyrite, galena, calcite. Au average grade 4.6 g/t. | Sulphide-pyrites, molybdenite rarely sphalerite. Au average grade 7.4 g/t. |
| Gold | Magmatic hydrothermal gold bearing fluids superimposing on a pre-deposited quartz-sulfide association. | Mineralized fluids are magmatic in origin, coming from large bodies of granodiorite and diorite. |
| Au reserves | 10.0 lakh tonns | Not estimated |
| Geological time scale | East Dharwar Craton Greenstone belt. | Greenstone belts of Tanzania gold revealed in protrozoic rocks |
| Age | 3.5 Ga | 1060 to 1920 Ma |

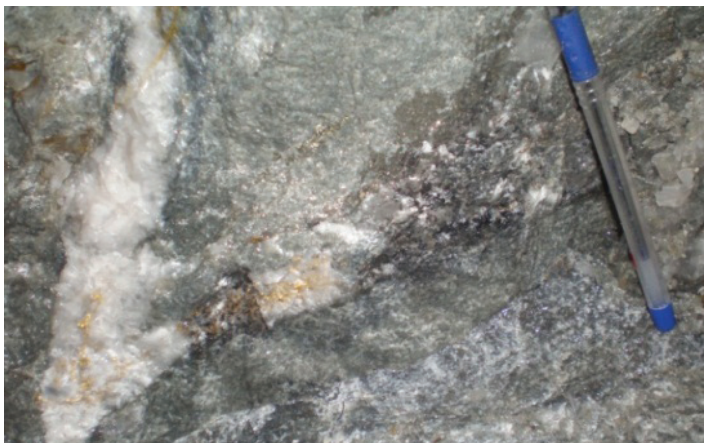

*Fig. 8 Intersection of quartz vein with coarse gold in exploratory underground development drive at ATR 13.*

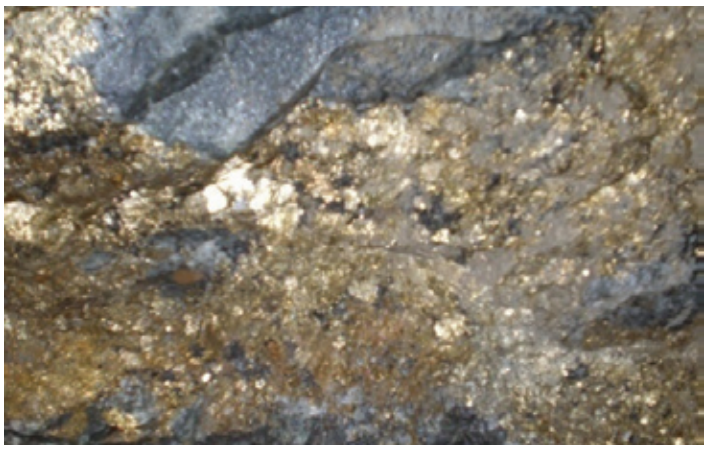

*Fig. 9 Sheets of Pyrite deposited on the Granodiorite in an underground tunnel at Autrad Gold Mine at ATR 13.*

intersected a crust of a fold with coarse gold nugget) in smoky quartz reef (Fig.8) thus confirming magmatic origin.

*Fig. 9 Metal detector used to trace the gold.*

At ATR 13 development drive found thick sheets of sulphide minerals such as pyrites, chalcopyrite and galena, molybdenite, rarely sphalerite spread on the granodiorite (Fig. 9). According to (Mnali SR, 1999) the age of the Saza-Chunya granitoid and slightly younger Illunga granite are1960 Ma and 1920 Ma respectively.

## 5.0 Structural controls in gold mineralization

In Chigargunta the rocks have been affected by several cross faults ranging from small to moderate scales, of which the major one trends NW-SE and this appears as a prominent line. As a result of this fault, the rocks occurring to the north-east of the fault are displaced northwest relative to the rocks occurring to the southwest of the fault. All the fault zones are marked by extensive silicification and brecciation of the country rocks. The prominent trend WNW-ESE with sub-vertical dips either way. The strike-slip varies from 60m to 90m. The stream flowing in Vappanapalli is on the fault plane. Few minor cross faults trending NW-SE to WNW-ESE with strike-slip varying from a few meters to a few tens of meters noticed at many places. These shear zones/faults are bear fissure filling by quartz veins (Kotnise, 2012-1).

Earlier Ziauddin and Ramachandra (1963) after detailed mapping show that a northerly plunging syncline has been refolded by NW – trending folds, which generated dextral en-echelon folds (Fig. 9) (BGML Mine plan, 1991). They also identified the presence of distinct domains of sinistral en-echelon folds. At least three sets of faults overprint the folds, the dominant one being NW-SE (F1) and parallel to the axial planes of the dextral folds.

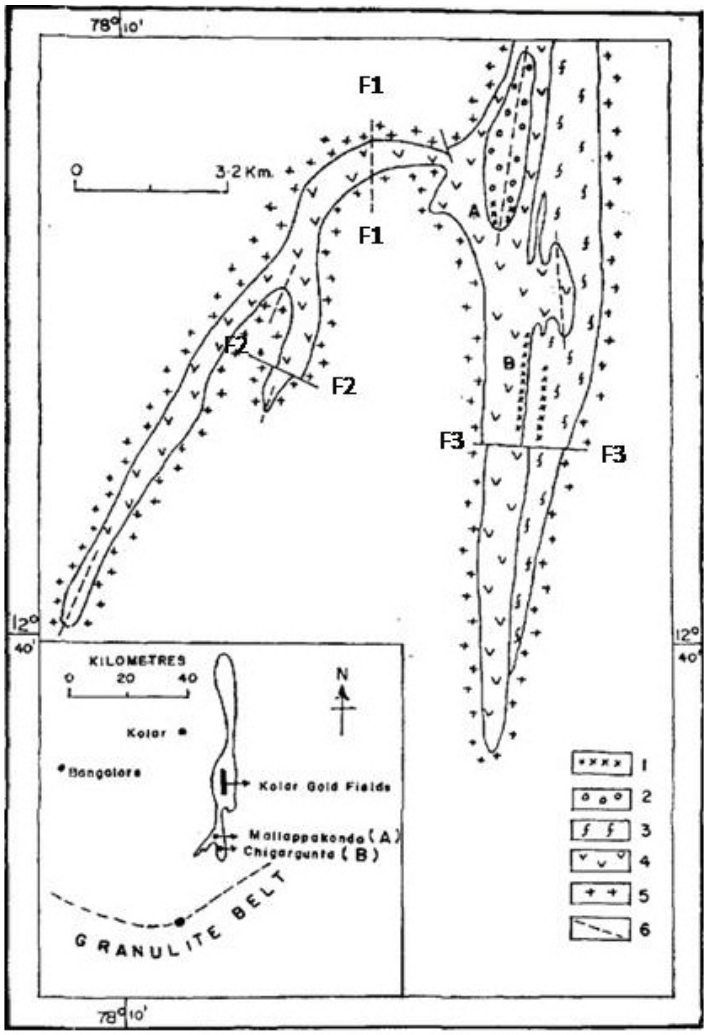


*Fig. 10 Sketch structural map of Chigargunta (BGML-Mine plan)*

The other faults include a NE-SW (F2) set parallel to the axial planes of sinistral en-echelon folds and a minor E-W (F3) set of cross faults. Thus, there are two sets of interpretations either related to the conjugate shear system or may represent opposite asymmetry of outcrop-scale folds related to a strongly non-cylindrical geometry. The shear zone near Chigargunta is mineralized and is highly fractured trending sub-vertical to vertical in some places it is steeply inclined.

Some of the exposures exhibit both dextral and sinistral shear bands occur together as conjugate sets appear to be synchronous. This has been described as a similar pattern by Mukhopadhay and Haimanot (1989) in gneiss and granites in KSB.

LANDSAT images of LGF processed for extracting geological features like faults, folds, and fracture zones and topographic ridges, and drainage segments and lineaments (Fig.12) (Kotnise, 2012-2). Geologic lineaments are important

for mineral exploration as they are the potential locations for hosting ore bodies that are deposited by ascending hydrothermal fluids.

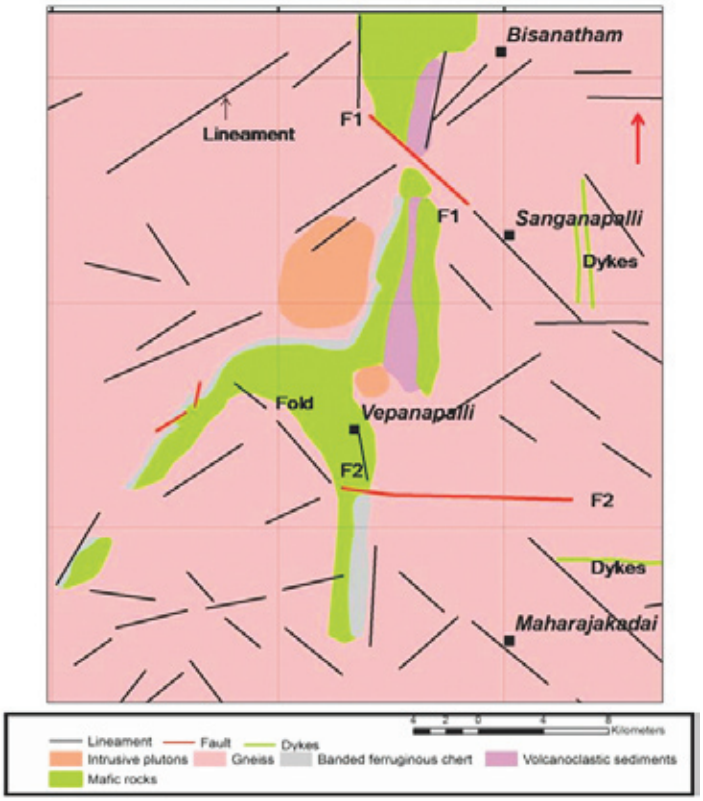


*Fig. 11 LANDSAT image showing the structural features of the southern part of the Kolar Schist Belt.*

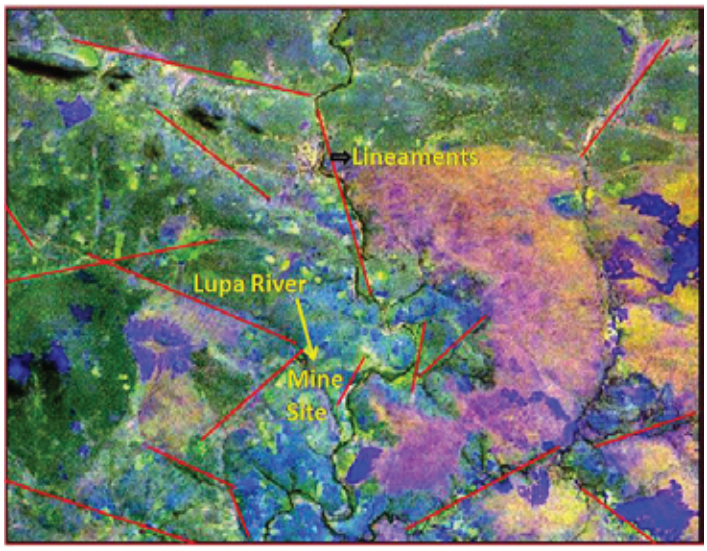


*Fig. 12 LANDSAT imageries of LGF show lineaments the favourable channels for gold mineralization.*

Indications of hydrothermal alterations are very prominently observed in the satellite image along with the shear zones, lineaments, and meandering domal structure by the Lupa River due to structural variance. The parallel quartz veinlets and /or silicified zones trend NNE to NE which dips gently to the southeast and becomes almost vertical at the deeper levels. Generally, gold-bearing gneiss is characterized by foliated and possibly sheared, brown iron oxide weathered, wall rock is sheared and altered due to high stress and temperature conditions associated with pyrite and carbonates. The MG Shear zone is at the lower western end of the mining property.

## Epigenetic gold mineralization

In epigenetic gold mineralization quite a good amount of fluid ($H_2O$-$CO_2$ rich) responsible for mineralization likely to be derived during shear deformation and regional scale retrograde metamorphism of high-grade rocks under greenschist-amphibolite facies conditions along MSZ and BSZ around 550 Ma (Srikantappa, 2001). It is believed that Fe-rich tholeiitic metavolcanic rocks have a good concentration of source of gold. The circulating hydrothermal fluid leached gold from mafic and the fluids were focused along major structural discontinuities like fractures following deformation. A general model has been presented on the evolution of gold which includes hydrothermal solution, transportation, and subsequent deposition in the favourable zones (Sharma SC, 2001).

## Formation of quartz veins

The conception of the formation of a quartz vein by processes analogous to granitization is very helpful in explaining features that have evaded the Geologists. The ionic migration studies have provided some ideas by which the observed processes of granitization have been accomplished. The resemblances of 'lode formation' was explained by D.H.McLaughlin, (1933) which opens up the vast possibilities of this line of reasoning "sharp even boundaries marking sudden changes from coarse vein material to highly altered rock are commonly difficult to explain on this basis (transfer of material by tenuous solutions under high pressure) yet the proof of replacement even under these conditions is often positive".

## Induction of gold in quartz

Gold is retained mostly in the quartz while its distribution is erratic which suggests that it was introduced after the consolidation and fracturing of the quartz. In this situation, the retention of gold in the quartz would be explained by the fact that the mineral sheared and provided intergranular passage for the Au ions since Au ions are too large to penetrate a silicate lattice. The adjacent lode and amphibolites schist would be impervious to the Au ions since they yielded by flow and not by fracture.

## 'Fault-valve model' for gold mineralization

In general, the gold mineralization in KSB is epigenetically formed after the peak of amphibolite facies of metamorphism.

Sibson, (1990) developed the 'fault – valve model' (Fig.13) the regional synclinal structure of KGF and Chigargunta can be interpreted to the hydrothermal ore-forming process by the fault – valve mechanism.

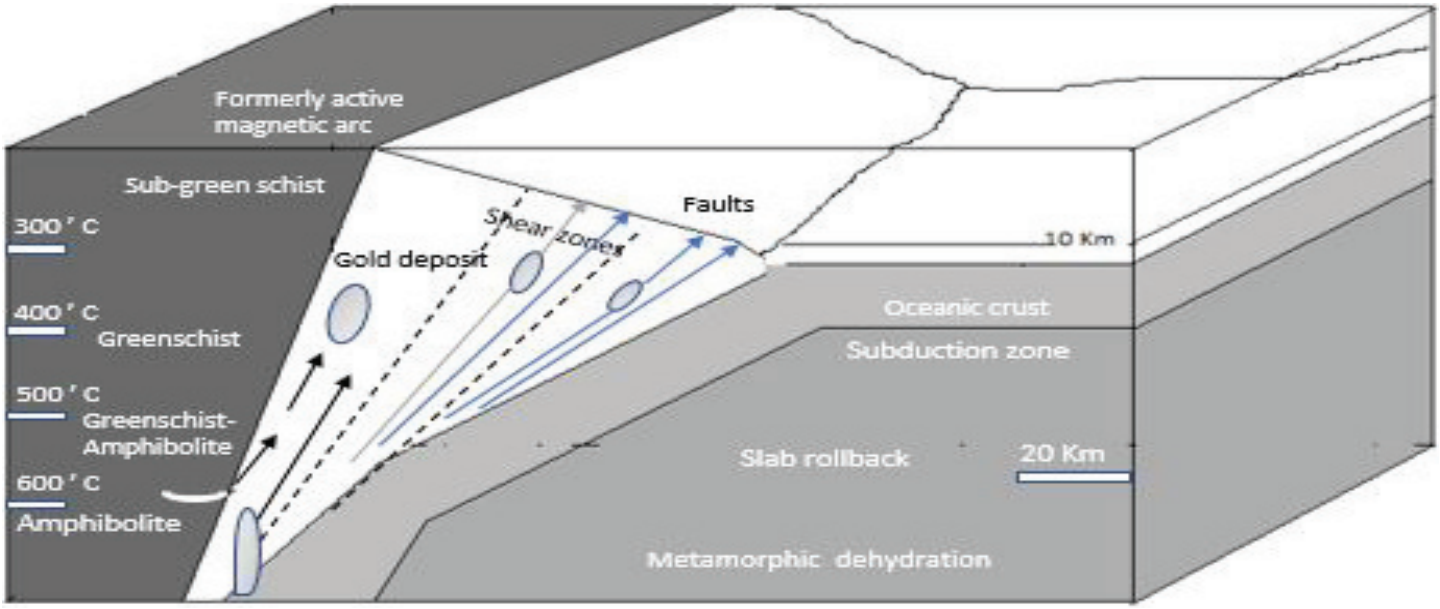


*Fig. 13 Fault-Valve model for the mode of gold mineralization.*

According to this model steeply dipping shear/fault oriented at a high angle under maximum compressive stress unsuitable for reactivation, which cuts the impermeable, non-fractured part of the seism orogenic crust, but does not allow fluid movement under normal stress conditions.

*Fig. 14 Fault -Valve fissure filling quartz vein.*

The gold-bearing quartz occurrences in shear/fault (Fig.14) fracturing may be formed by the reactivation of steep reverse faults opening due to tectonic regime as well resulted in the repeated folding and faulting forming small rafters in the schist belt.

## Geo-botanical similarities

The soil being the aggregate of rocks, so the rocks provide necessary minerals for the growth of the plant. Keeping this in view the researchers have traced the plants adjacent to the typical mineral deposits and associated with treating plants as a geo-botanical indicator for prospecting for minerals apart from the other tools used. The plants also have an affinity with the suitable soil to grow as the cotton in black soil.

Research has indicated that plants can reveal mineral anomalies (Cannon, et. al., 1996). The biogeochemical surveys conduct through plants show the presence of metal concentrates both in plants and soil (Malyuga, et al.,1964). Based on these observations were made to identify the vegetation in these schist belts.

Lush growth of Caesalphinacea trees/shrubs bearing yellow flowers (Fig. 15) present along the strike length in KSB in India from Srinivaspur, Karnataka to Naralapalli, Tamil Nadu

to and Chunya district, Matundasi. This plant appears to be a geo-botanical indicator for the presence of gold. Thus, there are significant similarities in the physiography, lithology and mode of gold mineralization hence there is ample scope for discovering potential deposits in Lupa Gold Field as similar to that of deposit mined at Kolar Gold Fields.

*Fig. 15 Caesalphinacea trees widely grown along the schist belt.*

## Conclusion

The characterization of epigenetic gold deposits in Chigargunta, the southern part of the KSB in India and Autrad mine deposit in the Ubendian belt in LGF, Tanzania support the concept of continental drifting. The study suggests the gold occurrence is significantly common related to host rock and structural unconformities. The source of primary gold particles believed to have been migrated from the granodiorites/diorite to favourable location along the sheared/fault systems attributing to the fault-value theory. Applying this concept in Chigargunta there is ample scope for discovery of new ore-shoots at the tail end of the KSB which is subjected to intense deformation like folding, refolding, faulting resulting in small rafters. However, in Autrad mine the intersection of coarse gold at the nose of a fold though measuring just about 30 cm resembles with the similar huge occurrence in nose of fold in east limb and west limb of Champion lode systems in KSB, KGF. Hence it is suggested a detailed investigation the Ubendian belt may lead to discovery of rich gold deposit as mined at KSB, Kolar Gold Fields, Karnataka.

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# RESERVE ESTIMATION OF A LIMESTONE MINE USING DATAMINE SOFTWARE

**Deepak Chandra Pandey[1], Dr. Anupam Bhatnagar[2]**

## *Abstract*

*In 21st century, we are so developed in the field of computerisation, we are using mine-planning software like Datamine to extract mineral in technical as well as in a planned way, therefore there will be a less mineral exploitation and we can use mineral in an optimised way. Computer aided valuation and mine design systems provide ease of extracting the mineral and also helps in reduce the fixed and operating cost of the mineral.*

*Block modelling is very important part for any mining project as it will decide the level of mechanisation required, the quantity and quality of mineral, profit and loss and also about the assets required, the method of working, machinery and other equipment required, so to minimise the human error and to do the work as early as possible now a days we are using different mining software for mine planning. This paper is about the geological modelling using inverse square distance and kriging method for an opencast limestone mine and its reserve estimation using the Datamine Software.*

*Keywords: Mining, Modelling, Reserve Estimation, Datamine software*

## INTRODUCTION

A geological model consists of a three-dimensional representation of an ore deposit constructed by resource geologists on the basis of their knowledge of the deposit, geological field observations, geophysical surveys, and drill hole logs and assays. A geological model that represents the spatial locations and extents of rock types or ore types is an essential input for mineral resources evaluation and mine planning and, as such, affects all subsequent stages of the mining process. [1-5]

Geological block models are used to generate economical block models by using unit costs and income. With known volume of a block, thickness and grade of ore at each particular block, it becomes possible to convert this information to economical aspect. (Volume * tonnage factor * grade = block reserve.) Economical block models have visual and numerical results; 3D appearances of them give an idea if and where an ore body is rich and how quality changes. Studies of validating geological models often concentrate on statistical and graphical analyses by comparing the models with the available data to detect inconsistencies. [5]

Resource estimation is used to determine and define the ore tonnage and grade of a geological deposit, from the developed block model. There are different estimation methods (see below) used for different scenarios dependent upon the ore boundaries, geological deposit geometry, grade variability and the amount of time and money available. Typical resource estimation involves the construction of a geological and resource model with data from various sources. Depending on the nature of the information and whether the data is hard copy or computerized, the principal steps of computer resource estimation are:

1. Creation, standardization and validation of the database
2. Section plotting and interactive geological modelling
3. Geostatistical analysis.
4. Block modelling and block estimation.

## GEOLOGICAL MODELLING

An orebody model serves as the geological basis of all resource estimation, an orebody modelling project starts with a critical review of existing drill hole and surface or underground sample data as well as maps and plans with current geological interpretation. [6] Drill hole and/or sample databases are set up to suit all the quantitative and qualitative information necessary to build a resource model. The creation of a geological model may include the following steps:

- Computer-based 3D orebody modelling
- Sectional, longitudinal, 3D and multi-seam modelling
- Geostatistical analysis, variographic analysis of composite spatial continuity

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## BLOCK MODELLING ESTIMATION

Once the geological modelling completed, the geological envelopes are divided into block models. Subsequently, the estimation of these blocks is done from "composites" that are point measures of the grade of ore in the rock. Several different mathematical methods can be used to do the estimation depending on the desired degree of precision, quality and quantity of data and of their nature. [6]

## NEAREST NEIGHBOUR METHOD

The nearest neighbour method assigns grade values to blocks from the nearest sample point to the block. Closest sample gets a weight of one; all others get a weight of zero. In two dimensions, this method generates a Voronoi diagram composed of polygons each with a unique grade; in three dimensions this method generates a Voronoi diagram composed of polyhedral each with a unique grade. In mathematics, a Voronoi diagram is a partitioning of a plane into regions based on distance to points in a specific subset of the plane. That set of points (called seeds, sites, or generators) is specified beforehand, and for each seed there is a corresponding region consisting of all points closer to that seed than to any other. These regions are called Voronoi cells. The Voronoi diagram of a set of points is dual to its Delaunay triangulation. Put simply, it's a diagram created by taking pairs of points that are close together and drawing a line that is equidistant between them and perpendicular to the line connecting them. That is, all points on the lines in the diagram are equidistant to the nearest two (or more) source points. [6]

## INVERSE DISTANCE WEIGHTING METHOD

The name given to this type of method was motivated by the weighted average applied, since it resorts to the inverse of the distance to each known point ("amount of proximity") when assigning weights.

The simplest weighting function in common usage is based upon the inverse of the distance of the sample from the point to be estimated, usually raised to the second power, although higher or lower powers may be useful.

Samples closer to the point of interest get a higher weighting than samples farther away. Samples closer to the point of estimation are more likely to be similar in grade. Such inverse distance techniques introduce issues such as sample search and declustering decisions, and cater for the estimation of blocks of a defined size, in addition to point estimates.

## KRIGING

In statistics, originally in geostatistics, Kriging or Gaussian process regression is a method of interpolation for which the interpolated values are modelled by a Gaussian process governed by prior covariances, as opposed to a piecewise-polynomial spline chosen to optimize smoothness of the fitted values. Under suitable assumptions on the priors, Kriging gives the best linear unbiased prediction of the intermediate values. Interpolating methods based on other criteria such as smoothness need not yield the most likely intermediate values. The method is widely used in the domain of spatial analysis and computer experiments.

The main venture in ordinary kriging is to build a variogram from the dissipate point set to be interpolated. A variogram comprises of two parts: an experimental variogram and a model variogram. Assume that the worth to be interpolated is alluded to as f. The experimental variogram is found by figuring the variance (g) of each one point in the set as for each of other points and plotting the variances versus separation (h) between the points. A few equations might be utilized to figure the variance, yet it is ordinarily calculated as half the difference in f squared. Once the experimental variogram is figured, the following step is followed to characterize a model variogram. A model variogram is a straightforward function that models the pattern in the experimental variogram. At small partition distances, the variance in f is small. As it were, points that are near one another have comparable f values. After a certain level of partition, the variance in the f qualities gets to be arbitrary to some degree and the model variogram levels out to a value corresponding to the average variance.

## BLOCK MODELLING: Case Study of a Limestone Mine

## GEOLOGY OF THE MINE

Barapar Limestone Beds belonging to Rohtas Stage, Semri Series of Lower Vindhyan Group occurs within the prospecting licence area. Detailed prospecting operation revealed the occurrence of thin limestone band. The strike of this thin limestone band in the area under investigation was observed as North 55o East - South 55o West. Dip of the beds is towards North 35° west and the amount of dip is between 10º to 15º. However, steep dips are not uncommon due to folding. The local geological succession established based on prospecting operations is as under:

- Soil (OB)
- Barapar Limestone
- Slaty Grey Magnesian Shales

Data from 195 drill holes has been used to generate the resource model. The dataset was made available in the form of Excel sheets in three different files. These files include Collars, Assays and the Lithology files. The drill holes are vertical and is regular with spacing of the holes varying from 100 to 200m.

## MINERALISATION

The deposit is almost horizontal, having dips ranging between 0.1 to 1 degrees. Most of the drill holes have been

drilled in a regular patter barring a few which do not fall on a particular section line. Therefore, transverse sections have been taken along the lines along which boreholes have been drilled. The inter-spacing of the section lines vary from 100 to 200m. In all, 26 sections have been generated within Studio using a series of sectional strings at irregular intervals. The sections are oriented in NNW-SSE direction as indicated in the figure-1:

## STATISTICAL ANALYSIS

Statistical analysis of the samples within the orebody is of prime importance as it provides basic information on the characteristics of the deposit.

The main objective of carrying out statistical analysis is to know about:

1. The distribution of the data.
2. The type of populations.
3. Expected ranges of values, detect extreme, possibly erroneous values.
4. Interdependence of various radicals.
5. To get early analysis of a deposit and to verify and interpret the sample values available.
6. To check the reliability of sampling and analytical techniques through check analysis and composite sample preparation.

Statistical analysis has been carried out considering only the samples within the mineralised body above a cut off grade of 34% CaO. The statistical parameters have been calculated for all the radicals.

| FIELD | N0. Of SAM-PLES | MIN | MAX | RANGE | MEAN | VARI-ANCE | STAND DEV | STAND ERR | SKEW-NESS | KUR-TOSIS | GEO MEAN |
|---|---|---|---|---|---|---|---|---|---|---|---|
| CAO | 1165 | 34.00 | 51.42 | 17.42 | 40.91 | 15.79 | 3.97 | 0.12 | 0.13 | -0.84 | 40.71 |
| FE2O3 | 1054 | 0.29 | 9.04 | 8.75 | 1.54 | 1.73 | 1.32 | 0.04 | 2.57 | 7.34 | 1.22 |
| AL2O3 | 1055 | 0.31 | 23.82 | 23.51 | 3.90 | 22.32 | 4.72 | 0.15 | 2.26 | 3.96 | 2.54 |
| MGO | 1165 | 0.61 | 8.20 | 7.59 | 3.14 | 3.05 | 1.75 | 0.05 | 0.90 | -0.18 | 2.70 |
| SIO2 | 1055 | 0.35 | 28.83 | 28.48 | 13.30 | 37.52 | 6.13 | 0.19 | -0.75 | -0.11 | 9.99 |

## HISTOGRAMS

Histograms have been generated for all the radicals to know their distribution pattern which helps in identifying the presence of outliers and removing them for better estimations. It can be seen from the distribution of CaO, $SiO_2$, $Fe_2O_3$, $Al_2O_3$ MgO that these show near normal distributions with CaO showing a negative skewness whereas others show a positive skewness figure-2.

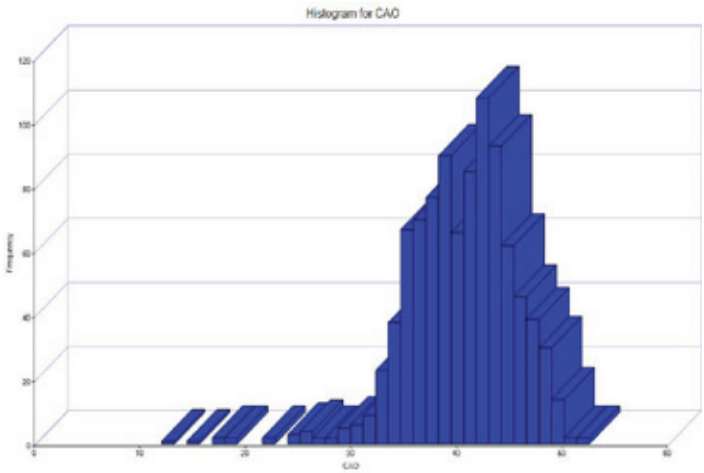


*Figure 2: Frequency distribution of CaO values within ore (limestone body)*

## CORRELATION STUDY

In order to see the interdependence of one radical over another, correlation study has been carried out. The correlation study shows that CaO values have negative correlations with all radicals which mean a tendency for large values of CaO to be associated with small values of other radicals and vice versa.

**Table 2**: Correlation Matrix

| | CaO | $SiO_2$ | $Fe_2O_3$ | $Al_2O_3$ | MgO |
|---|---|---|---|---|---|
| CaO | 1.0000 | | | | |
| $SiO_2$ | -0.5306 | 1.0000 | | | |
| $Fe_2O_3$ | -0.3656 | -0.4132 | 1.0000 | | |
| $Al_2O_3$ | -0.2515 | -0.6359 | 0.8031 | 1.0000 | |
| MgO | -0.6036 | 0.5181 | -0.2343 | -0.2592 | 1.0000 |

## VARIOGRAPHY

In order to examine the spatial continuity of the grades in orthogonal directions, two experimental variograms were generated with differing search parameters, one planner and the second down-the-hole. Planner variograms were

drawn at every 45 degrees to find out the continuity in various directions.

Since the distance between samples varies from 100 to 200 m, a lag distance of 100m was chosen for drawing variograms in the horizontal planes whereas lag distance of 1.0m (composited length) was taken for drawing down-the-hole variogram. The down-the-hole variograms also provided invaluable evidence on grade continuity at short distances.

**Table 3**: Experimental Variogram Parameters

| Selection Criteria | Plan | DTH |
|---|---|---|
| Lag Distance (m) | 100 | 1.0 |
| Lag Tolerance (m) | 50 | 0.5 |
| No. of Lags | 25 | 99 |
| Horizontal Increments | 45 | - |
| Horizontal Regularization Angle (o) | 22.5 | - |
| No. of Horizontal azimuths | 4 | - |
| Key-field | - | BHID |

## MODELLED VARIOGRAMS

For all the radicals 0 and 90 were found Best fit variograms thus those were utilized to deduce the variograms model parameters. Each of the experimental variograms was modelled using interactive Variogram fitting in Studio. The table-4 provide details of rotations, structures, ranges,

nugget variance and spatial variance for each of the grades examined. All variograms are fitted to a single structure spherical model.

The variographic model parameters such as nugget effect, population variance and radius of influence for various grade fields have been estimated as follows:

**Table 4**: Variographic Model Parameters

| Param-eters / Grade Field | Nugget value | Spatial variance | Range of influence X, Y and Z | | |
|---|---|---|---|---|---|
| CaO | 1.94 | 17.462 | 344 | 195 | 4 |
| $SiO_2$ | 3.88 | 34.923 | 373 | 66 | 13 |
| $Al_2O_3$ | 0.001 | 19.401 | 309 | 66 | 14 |
| $Fe_2O_3$ | 0.095 | 1.858 | 409 | 84 | 14 |
| MgO | 0.048 | 3.428 | 318 | 117 | 9 |

## BLOCK MODELLING

An appropriate block model has been generated to fill the orebody wireframe with cells in order to describe tonnage as well as grade. The parent block size of 50x50x1 has been chosen. The blocks are orthogonal and have not been rotated.

Filling of the orebody cells has been undertaken in XY plane direction with splitting of the cells in vertical direction due to the major extension in XY direction.

Five separate models have been created – one for the wireframe of limestone body at cut off of > 34% CaO, second for the waste above the limestone body, the third for internal waste lying within the limestone body, fourth for the waste below the limestone body, and a separate model for soil. The block models were then combined together to create a single block model.

The block model has been validated by means of a volume comparison between the ore body wireframes and the block model with an accuracy of 99.8%. The subsequent geological block model is displayed in figure-3.

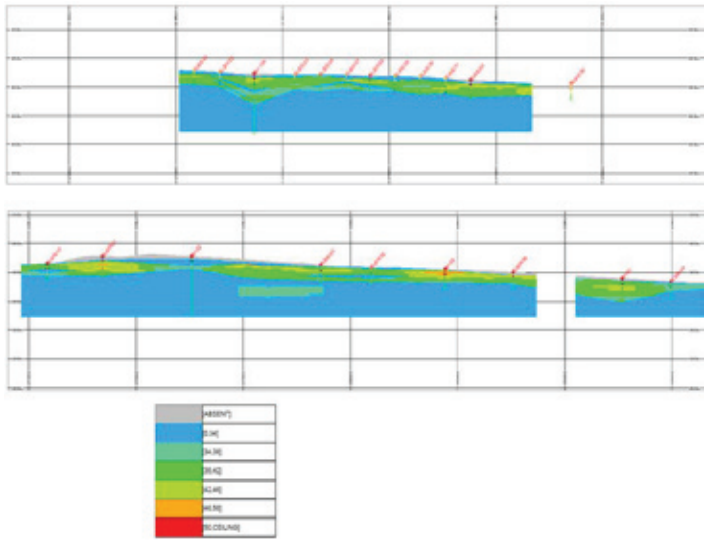

*Figure 3: Vertical sections of the block Model along section lines 5 and 20*

## Estimation Techniques

The assays radicals have been estimated into the geological block model using both ordinary kriging and inverse power of distance. This allows a comparison and validation of the techniques utilized in grade estimation. Ordinary Kriging has been applied utilising the modelled variograms parameters.

A minimum of 3 samples and maximum of 20 samples has been used for primary search volume and second and third expansion factors have been used for estimation to cover the areas where samples are available at farther distances.

In Studio grade is estimated by selecting each cell of the block model one by one and then using the samples lying within the search volume specified the estimation method and variogram parameters, the grades are then assigned to each cell. The Figure 4 below shows a block model with the assigned grades

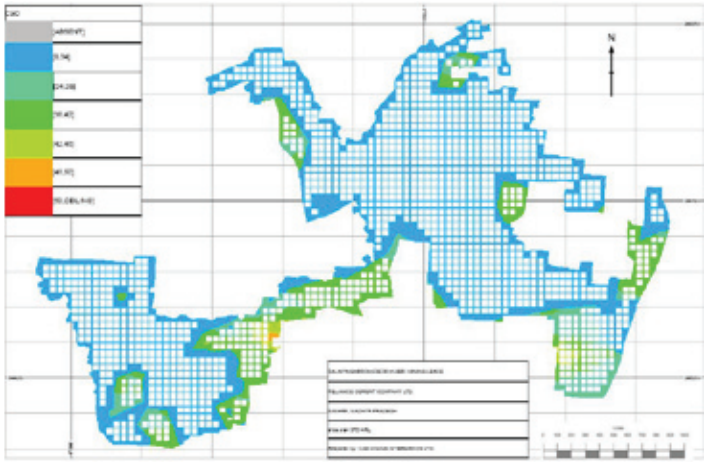

*Figure 4: Geological block model of limestone (370 mRL)*

## RESULTS & DISCUSSIONS

### RESERVE ESTIMATION

Geological reserves have been estimated using different criteria. The evaluation has been done on orebody block model and combine model of ore and waste. As already mentioned, the modelling has been done for limestone with a cut- off grade of 34% CaO. The internal waste has been segregated and modelled separately. The grades have also been estimated for this internal waste. The two models – limestone above cut-off grade of 34% and the internal waste are combined together to create final ore model.

Since the density data was not available within drill hole data, bulk density of 2.5 has been considered for limestone and 1.5 for soil for reserve computation purpose.

The total reserves within the orebody with average grade of all the radicals are as indicated in the following tables by both the methods.

**Table 5**: Geological reserve by Inverse Square Distance Method

| CATEGORY | DEN-SITY | VOLUME | TONNES | MT | CAO_ IPD | SIO2_ ISD | AL2O3_ ISD | FE2O3_ ISD | MGO_ ISD | LSF_ ISD |
|---|---|---|---|---|---|---|---|---|---|---|
| TOP SOIL | 1.5 | 4554222 | 6831332 | 6.83 | - | - | - | - | - | - |
| OB (WASTE ABOVE LST) | 1.5 | 4570629 | 6855944 | 6.86 | 14.48 | 34.89 | 15.97 | 7.55 | 3.94 | 15.21 |
| LST (CAO>34%) | 2.5 | 36511771 | 91279428 | 91.28 | 40.33 | 15.14 | 3.02 | 1.46 | 3.36 | 89.85 |
| IB (CAO<34%) | 1.5 | 518820 | 778230 | 0.78 | 30.25 | 23.52 | 4.25 | 1.93 | 6.50 | 43.76 |
| WASTE BELOW LST | 1.5 | 115566362 | 173349543 | 173.35 | 28.54 | 22.95 | 4.38 | 1.98 | 8.17 | 41.63 |
| | | | | | | | | | | |
| LST INCLUDING INTERNAL WASTE | 2.48 | 37030591 | 92057658 | 92.06 | 40.24 | 15.21 | 3.03 | 1.47 | 3.38 | 89.46 |

**Table 6**: Geological reserve by Ordinary Kriging Method

| CATEGORY | DEN-SITY | VOLUME | TONNES | MT | CAO_ OK | SIO2_ OK | AL2O3_ OK | FE2O3_ OK | MGO_ OK | LSF_ OK |
|---|---|---|---|---|---|---|---|---|---|---|
| TOP SOIL | 1.5 | 4554222 | 6831332 | 6.83 | - | - | - | - | - | - |
| OB (WASTE ABOVE LST) | 1.5 | 4570629 | 6855944 | 6.86 | 14.14 | 34.80 | 16.20 | 7.98 | 3.62 | 14.98 |
| LST (CAO>34%) | 2.5 | 36511771 | 91279428 | 91.28 | 40.28 | 15.37 | 3.02 | 1.51 | 3.40 | 87.75 |
| IB (CAO<34%) | 1.5 | 518820 | 778230 | 0.78 | 30.19 | 23.42 | 4.39 | 1.98 | 6.46 | 43.62 |
| WASTE BELOW LST | 1.5 | 115566362 | 173349543 | 173.35 | 28.54 | 22.97 | 4.49 | 2.02 | 8.12 | 41.50 |
| | | | | | | | | | | |
| LST INCLUDING INTERNAL WASTE | 2.49 | 37030591 | 92057658 | 92.06 | 40.19 | 15.43 | 3.03 | 1.51 | 3.43 | 87.38 |

## CONCLUSIONS

1. Geological sections are made throughout the mineral zone and level wise grade are estimated.
2. Geological block modelling is done using inverse square distance and ordinary kriging method, almost value of radical is same from both the method as deposit is regular.
3. Geological Reserve is estimated including internal waste and without internal waste.
4. Datamine reduce the block modeling generation time almost seventy percentage as compared to conventional method.

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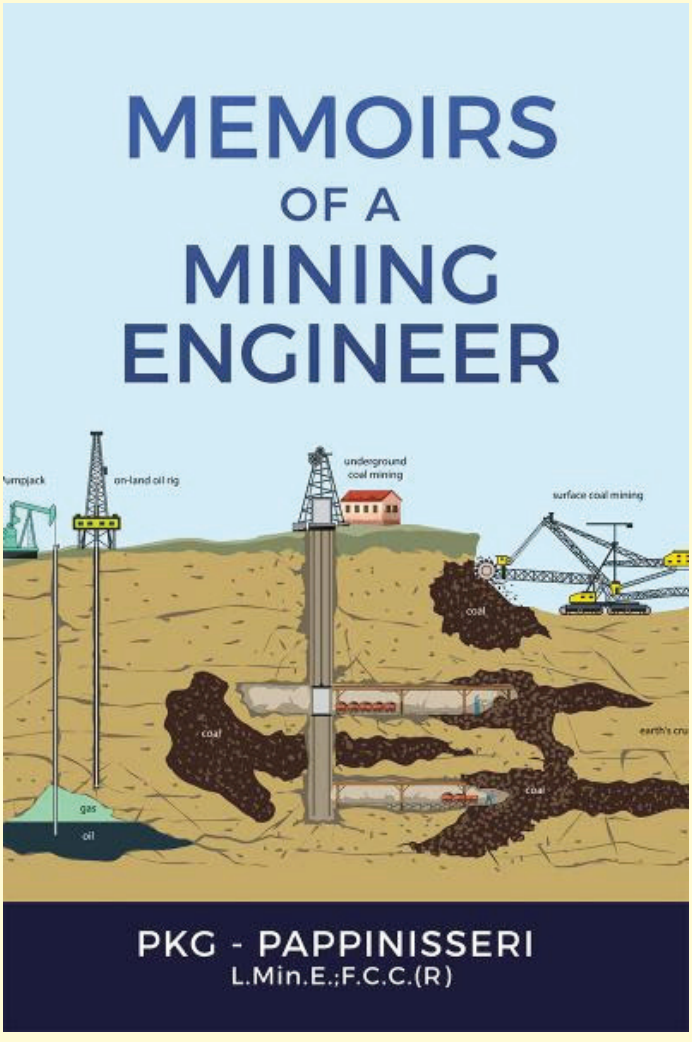
## BOOK REVIEW




### MEMOIRS OF A MINING ENGINEER

A veteran mining professional the author explains in simple language what is mining and what do the mining engineers do and what kind of management tools help you to achieve your career dreams. Hailing from a humble background, citing his own example in this memoir, he underscores the point that to be successful one need not be from top notch engineering institute, extra brilliant and super smart. While narrating his professional life as mining engineer, the book also highlights the importance of mining for the progressive growth of society which many of us are not aware of.

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**K. K. Biran**, *Past President –MMEA*

*(Continued from page 15)*

➤ **Coal ministry hasn't taken due responsibility as watchdog for CMPFO: Parliamentary panel**

A parliamentary panel has said the coal ministry has not taken due care of its responsibility as a watchdog for CMPFO, and stressed that financial irregularities could have been avoided if the government had been vigilant enough in monitoring the activities of the Coal Mines Provident Fund Organisation (CMPFO). CMPFO is a body that takes care of social security of coal mines workers.

"The committee (PAC) notes that the Ministry of Coal has been apparently found severely wanting in discharging its nodal administrative role, which resulted in financial mis-management by CMPFO," according to a recent report of the Public Accounts Committee (PAC), chaired by Congress leader Adhir Ranjan Chowdhury.

Though CMPFO enjoys functional autonomy, the nodal administrative ministry cannot shy away from its responsibility and accountability on the grounds of autonomy given to the organisation, it said

The PAC, it said, is "aghast to note that it is only after CAG report No. 12 of 2017 that brought out the financial irregularities, the issues of financial impropriety by CMPFO came to the notice of the officials of Ministry of Coal."

As per mandate, a senior-level officer not below the rank of joint secretary is the nominee of the ministry to the the Board of Trustees (BoT). But, it is astonishing to note that even after due representation, the nodal ministry has not properly executed their responsibility and defined role.

The ministry cannot abdicate its role of being the administrative body just by conveying that CMPFO has been delegated with necessary powers, it said.

The committee, therefore, exhorted the ministry to ensure that the activities of CMPFO are overseen with due care to prevent instances, such as the unwarranted tranfer of funds in CMPFO from provident fund account to pension fund account in the future.

"The committee is of the considered view that had the ministry been vigilant enought in monitoring the activities of CMPFO, particulary on account of the fact that the ministry's nominee is a part of BoT, the financial irregularities that came to the notice could have been avoided," it said.

The committee in this regard stressed the need on the part of the coal ministry to discharge the administrative and supervisory role of being a nodal ministry at all times with due diligence and sincerity.

*PTI | Apr 16, 2021*

➤ **Hindustan Zinc appoints women as underground mine managers**

Hindustan Zinc, a Vedanta group company, has appointed Sandhya Rasakatla as the country's first woman underground mine manager and Yogeshwari Rane as underground mine development manager, the company said in a release on Friday.

Rasakatla assumed the role as mine manager of HZL's Zawarmala mine while Rane is appointed head planning & development for Kayad mine. Both the women are also the first women in Indian mining to receive the 'First Class Mines Manager' certificate of competency in the "Unrestricted" category, the company said in the press release.

"Women being allowed in mining has been a revolutionary decision. This is an opportunity for us and the women mining engineers out there to bring about a societal change," said Arun Misra, CEO, Hindustan Zinc. "We have embraced this and have given an equal platform for our women engineers in our mining operations...This is just a stepping stone for young women who aspire to be leaders in the mining industry," he added.

*Rica Bhattacharyya, ET Bureau | Apr 09, 2021*

➤ **Vedanta to set up a new copper smelter with an investment of Rs 10,000 crore in a coastal state, submits EoI**

Anil Agarwal-led Vedanta Ltd is planning to set up a new copper smelter with an investment of around Rs 10,000 crore in partnership with the state government said the company through an expression on interest (EoI) submitted on Thursday.

"We are looking to partner with state governments for setting up a copper smelter in a coastal region in India," the company said in its EoI statement.

*Bhavya Dilipkumar, ET Bureau | Apr 02, 2021*

# CONFERENCES, SEMINARS, WORKSHOPS ETC.

## ABROAD

**10-11 Jun 2021**: **ICAME 2021- International Conference on Applied Mineralogy and Environment** in Copenhagen, Denmark. For more details, please visit: https://waset.org/applied-mineralogy-and-environment-conference-in-june-2021-in-copenhagen

**15-16 Jun 2021**: **International Conference on Mining Geology and Coal Exploration ICMGCE** in Toronto, Canada. Website URL: https://waset.org/mining-geology-and-coal-exploration-conference-in-june-2021-in-toronto; Contact URL: https://panel.waset.org/Support

**23-25 Jun 2021**: **MILL OPERATORS CONFERENCE 2021**. Online conference organized by AusIMM Brisbane, Australia

**29-30 Jun 2021**: **ICAG 2021 - International Conference on Advances in Geochronology** in Dubai, United Arab Emirates. For more details, please visit: https://waset.org/advances-in-geochronology-conference-in-june-2021-in-dubai

**1-2 Jul 2021**: **MINE WASTE AND TAILINGS CONFERENCE 2021**. Online conference organized by AusIMM Brisbane, Australia

**26-27 Jul 2021**: **OPEN PIT OPERATORS CONFERENCE 2021**. Online conference organized by AusIMM Perth, Australia

**22-23 Jul 2021**: **International Conference on Mining and Economic Geology ICMEG** in Berlin, Germany. Website URL: https://waset.org/mining-and-economic-geology-conference-in-july-2021-in-berlin; Contact URL: https://panel.waset.org/Support

**22-23 Jul 2021**: **International Conference on Geology, Mineral Exploration and Mining ICGMEM** in Rome, Italy. Website URL: https://waset.org/geology-mineral-exploration-and-mining-conference-in-july-2021-in-rome; Contact URL: https://panel.waset.org/Support

**23-24 Aug 2021**: **ICCGG 2021 - International Conference on Computational Geology and Geosciences** in Rome, Italy. For more details, please visit: https://waset.org/computational-geology-and-geosciences-conference-in-july-2021-in-rome

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**12th Sep 2021**: **International Conference on Geological and Environmental Sustainability (ICGES-21)** in Kuching, Sarawak, Canada. Contact Info: Phone: +91 8870915303; Email: info@scienceleagues.com

**20-21 Sep 2021**: **ICGG 2021 - International Conference on Geochronology and Geography** in Toronto, Canada. For more details, please visit: https://waset.org/geochronology-and-geography-conference-in-september-2021-in-toronto

**28-29 Sep 2021**: **NEW LEADERS CONFERENCE 2021**. Online conference organized by AusIMM Brisbane, Australia

**6-7 Oct 2021**: **ICEGGE 2021 - International Conference on Engineering Geology and Geomorphology Engineering** in Beijing, China. For more details, please visit: https://waset.org/engineering-geology-and-geomorphology-engineering-conference-in-october-2021-in-beijing

**18-19 Oct 2021**: **ICEG 2021 - International Conference on Earthquake Geology** in Rome, Italy. For more details, please visit: https://waset.org/earthquake-geology-conference-in-october-2021-in-rome

**21-22 Oct 2021**: **ICRSSGA 2021- International Conference on Remote Sensing Sensors for Geoscience Applications** in Athens, Greece. For more details, please visit: https://waset.org/remote-sensing-sensors-for-geoscience-applications-conference-in-october-2021-in-athens

**8-10 Nov 2021**: **IRON ORE CONFERENCE 2021**. Online conference organized by AusIMM Perth, Australia

**8-9 Nov 2021**: **ICEGGP 2021 - International Conference on Environmental Geology and Geological Problems** in Istanbul, Turkey. For more details, please visit: https://waset.org/environmental-geology-and-geological-problems-conference-in-november-2021-in-istanbul

**2-3 Dec 2021**: **ICRMGEA 2021 - International Conference on Rock Mechanics for Geotechnical Engineering Applications** in Tokyo, Japan. For more details, please visit: https://waset.org/rock-mechanics-for-geotechnical-engineering-applications-conference-in-december-2021-in-tokyo

**6-7 Dec 2021**: **ICCGM 2021 - International Conference on Computational Geosciences and Mathematical Modelling** in Kuala Lumpur, Malaysia. For more details, please visit: https://waset.org/computational-geosciences-and-mathematical-modelling-conference-in-december-2021-in-kuala-lumpur

**6-8 Dec 2021**: **INTERNATIONAL FUTURE MINING CONFERENCE 2021**. Online conference organized by AusIMM Perth, Australia

**13-14 December 2021**: **ICRGGACS 2021 - International Conference on Regional Geology, Geologic Analysis and Computer Simulations** in Cairo, Egypt. For more details, please visit: https://waset.org/regional-geology-geologic-analysis-and-computer-simulations-conference-in-december-2021-in-cairo

**15-16, April 2022**: **ICGGG 2022 - International Conference on Geochronology, Geology and Geophysics** in Cape Town, South Africa. For more details, please visit: https://waset.org/geochronology-geology-and-geophysics-conference-in-april-2022-in-cape-town

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